CHAPTER 8. LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSES

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CHAPTER 8. LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSES

8.1 INTRODUCTION

This chapter describes the methodology for analyzing the economic impacts of possible energy conservation standards being developed for packaged terminal air conditioners (PTACs) and packaged terminal heat pumps (PTHPs) equipment on individual customers. The effect of amended standards on individual customers usually includes a reduction in operating cost and an increase in purchase cost. This chapter describes two metrics used in the analysis to determine the economic impact of standards on individual commercial customers:

- Life-cycle cost (LCC) is the total customer cost over the life of an appliance or equipment, including purchase costs and operating costs (which in turn include maintenance, repair, and energy costs). Future operating costs are discounted to the time of purchase, and summed over the lifetime of the appliance or equipment.
- Payback period (PBP) measures the amount of time it takes customers to recover the assumed higher purchase price of more energy-efficient equipment through reduced operating costs.

DOE conducted the LCC and PBP analysis using a spreadsheet model developed in Microsoft Excel. When combined with Crystal Ball (a commercially available software program), the LCC and PBP model generates a Monte Carlo simulation to perform the analysis by incorporating uncertainty and variability considerations in certain of the key parameters as discussed below.

Inputs to the LCC and PBP analyses of PTAC and PTHP equipment are discussed in sections 8.2 and 8.3, respectively. Results for each metric are presented in sections 8.4 and 8.5, respectively. Key variables and calculations are presented for each metric. The calculations discussed here were performed with a series of Microsoft Excel spreadsheets which are accessible over the Internet (http://www.eere.energy.gov/buildings/appliance_standards/commercial/packaged_ac_hp.html).

Details of and instructions for using the spreadsheets are discussed in appendix D. A more complete set of results of the analyses are presented in appendix E.

8.1.1 General Approach for Life-Cycle Cost and Payback Period Analyses

Recognizing that each business that uses PTAC and PTHP equipment is unique, DOE analyzed variability and uncertainty by performing the LCC and PBP calculations detailed here for four types of commercial businesses, each of which tends to have different costs of financing because of the nature of the business. DOE identified these four types of businesses, which represent over 95 percent of the end user sectors of PTAC and PTHP equipment. The first type of business is a “large chain” hotel or motel, which, DOE believes, has access to a wide range of financing options and thus a relative low financing costs. The second type is an “independent” hotel or motel, which is not affiliated with a national chain, which has fewer financing options and thus a relative high financing costs. A third type of business is called “health care” and includes nursing homes, as well as assisted living and long-term care facilities, which, similar to the large chain hotel, has a relative low financing costs. The fourth type is called “office” and applies to small office buildings that are occupied by offices of non-hospital medical professionals such as physicians and dentists which, DOE believes, has the fewest financing options, and as a result, the highest costs. DOE derived the financing costs based on data from the Damodaran Online site.[1]

The LCC analysis used the estimated energy use for each PTAC or PTHP unit as described in the energy use characterization analysis in Chapter 7 of the TSD. Energy use of PTACs and PTHPs is sensitive to climate, so it varies by State within the United States. Aside from energy use, other important factors influencing the LCC and PBP analyses include energy prices, installation costs, equipment distribution markups, and sales tax. At the National level, the LCC spreadsheets explicitly modeled both the uncertainty and the variability in the model’s inputs, using probability distributions based on the shipment of PTAC and PTHP equipment to different States and business types.

As mentioned above, DOE generated LCC and PBP results as probability distributions using a simulation based on Monte Carlo analysis methods, in which certain key inputs to the analysis consist of probability distributions rather than single-point values. Therefore, the outcomes of the Monte Carlo analysis can also be expressed as probability distributions. As a result, the Monte Carlo analysis produces a range of LCC and PBP results. A distinct advantage of this type of approach is that DOE can identify the percentage of customers achieving LCC savings or attaining certain PBP values due to an increased efficiency level, in addition to the average LCC savings or average PBP for that efficiency level.

The LCC and PBP results are displayed as distributions of impacts compared to the baseline conditions. As described in Chapter 7, the baseline efficiency level is defined as the PTAC and PTHP efficiency level specified by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) and the Illuminating Engineering Society of North America (IESNA) Standard 90.1-1999, “*Energy Standard for Buildings Except Low-Rise Residential Buildings”* (ASHRAE/IESNA Standard 90.1-1999). Results are presented at the end of this chapter. A variety of graphic displays can be created to illustrate the implications of the analysis. Examples of graphic displays are (1) a cumulative probability distribution showing the percentage of PTAC and PTHP equipment in U.S. commercial buildings that would experience a net LCC savings, and (2) a cumulative frequency chart depicting variation in PBP for each PTAC and PTHP efficiency level considered.

All analyses were performed under the assumption that the current R-22 refrigerant would have been displaced by an alternative refrigerant in 2010 due to the Clean Air Act. The analysis methodology and results presented in this chapter assume that all equipment manufactured after 2010 will use R-410A. .

8.1.2 Overview of Life-Cycle Cost and Payback Period Analyses Inputs

The LCC is the total customer cost over the life of the equipment, including purchase cost and operating cost (including energy cost). Future operating costs are discounted to the time of purchase and summed over the lifetime of the equipment. The PBP is the increase in purchase cost of higher efficiency equipment divided by the change in annual operating cost (as a result of lower energy consumption) of the equipment. It represents the number of years it will take the customer to recover the increased purchase cost through decreased operating costs. In the calculation of PBP, future costs are not discounted.

Inputs to the LCC and PBP analyses are categorized as follows: (1) inputs for establishing the purchase cost, otherwise known as the total installed cost, and (2) inputs for calculating the operating cost (i.e., energy, maintenance, and repair costs).

The primary inputs for establishing the total installed cost are:

- *Baseline manufacturer selling price*: The baseline manufacturer selling price (MSP) is the price charged by the manufacturer to either a wholesaler or customer for equipment meeting existing minimum efficiency (or baseline) standards. The manufacturer selling price includes a markup that converts the cost of production (i.e., the manufacturer cost) to a manufacturer selling price.
- *Standard-level manufacturer selling price increase*: The standard-level MSP is the incremental change in MSP associated with producing equipment at each of the higher standard levels.
- *Markups and sales tax*: Markups and sales tax are the markups and sales tax associated with converting the MSP to a customer price. The markups and sales tax are described in detail in Chapter 6, Markups for Equipment Price Determination.
- *Installation price*: Installation price is the cost to the customer of installing the equipment. The installation price represents all costs required to install the equipment but does not include the marked-up customer equipment price. The installation price includes labor, overhead, and any miscellaneous materials and parts. Thus, the total installed cost equals the customer equipment price plus the installation price.

The primary inputs for calculating the operating cost are:

- *Equipment energy consumption*: The equipment energy consumption is the site energy use associated with the use of the PTAC and PTHP equipment to provide space-conditioning to the building. Chapter 7, Building Energy Use Characterization, provides complete details on the PTAC and PTHP equipment energy use simulations and their results.
- *Electricity prices*: Electricity prices used in the analysis are the price per kilowatt-hour in cents or dollars ($/kWh) paid by each customer for electricity. Electricity prices are determined using average commercial electricity prices in each State, as determined from Energy Information Administration (EIA) data for 2007[2]. The 2007 average commercial prices were then modified to reflect the fact that the four types of businesses that use the PTAC and PTHP equipment pay prices that, on average, are either slightly higher or lower than the 2007 average commercial prices, based on the 2003 Commercial Building Energy Consumption Survey (CBECS) data.[3]
- *Electricity price trends*: The EIA's *Annual Energy Outlook 2008* (*AEO 2008*) is used to forecast electricity prices into the future[4]. For the results presented in this chapter, DOE used the *AEO 2008* reference case to forecast future electricity prices.

- *Maintenance costs*: The labor and material costs associated with preventative maintenance of the equipment (e.g., cleaning heat exchanger coils and drain pans, changing air filters, etc.).
- *Repair costs*: The labor and material costs associated with repairing or replacing components that have failed.
- *Lifetime*: The age at which the PTAC or PTHP equipment is retired from service.
- *Discount rate*: The rate at which future costs are discounted to establish their present value.

Figure 8.1.1 graphically depicts the relationships between the installed cost and operating cost inputs for the calculation of the LCC and PBP. Table 8.1.1 summarizes the values for the various inputs to the calculation of the LCC and PBP. As noted earlier, most of the inputs are characterized by probability distributions that capture variability in the input variables. Also listed in Table 8.1.1 are chapters in the TSD, where more detailed information on the input variables can be found.

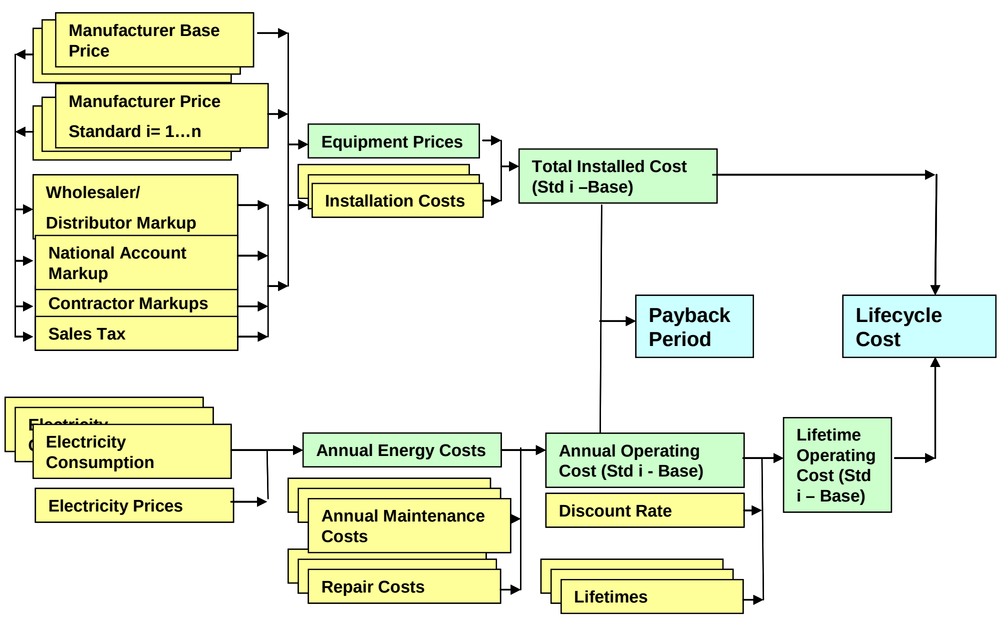

Figure 8.1.1 Flow Diagram of Inputs for the Determination of LCC and PBP

Table 8.1.1 Summary of Inputs and Key Assumptions used in the LCC and PBP Analyses

Inputs	Description
Affecting Installed Costs	
Equipment Price	Derived by multiplying MSP (from the engineering analysis) by wholesaler markups and contractor markups plus sales tax (from markups analysis). Used the probability distribution for the different markups to describe their variability.
Installation Cost	Includes installation labor, installer overhead, and any miscellaneous materials and parts, derived from *RS Means Costworks 2008*.
Affecting Operating Costs	
Annual Energy Use	Derived from whole-building hourly energy use simulation for PTACs or PTHPs in a representative hotel/motel building in various climate locations (from energy use characterization analysis). Used annual electricity use per unit. Used the probability distribution to account for which State a unit will be shipped to, which in turn affects the annual energy use.
Electricity Price	Calculated average commercial electricity price in each State, as determined from EIA data for 2007. Used the AEO2008 forecasts to estimate the future electricity prices. Used the state probability distribution for the electricity price.
Maintenance Cost	Annual maintenance cost did not vary as a function of efficiency.
Repair Cost	Estimated the annualized repair cost for baseline efficiency PTAC and PTHP equipment as $15, based on costs of extended warranty contracts for PTACs and PTHPs. Assumed that repair costs would vary in direct proportion with the MSP at higher efficiency levels because it generally costs more to replace components that are more efficient.
Affecting Present Value of Annual Operating Cost Savings	
Equipment Lifetime	Used Weibull probability distribution of lifetimes, with mean lifetime for each of four equipment classes assumed to be 10 years and maximum lifetime of 20 years, based on literature reviews and consultation with industry experts.
Discount Rate	Mean real discount rates ranging from 5.53 percent for large hotel chains to 8.14 percent for small office owners. Used the probability distribution for the discount rate.
Date Standards Become Effective	September 30, 2012 (four years after the publication of the final rule)
Analyzed Efficiency Levels	
Analyzed Efficiency Levels	Baseline efficiency levels (ASHRAE/IESNA Standard 90.1-1999) and five higher efficiency levels for six equipment classes (DOE also considered levels that were combinations of efficiency levels for PTACs and PTHPs).

All of the inputs depicted in Figure 8.1.1 and summarized in Table 8.1.1 are discussed in sections 8.2 and 8.3.

8.2 LIFE-CYCLE COST ANALYSIS INPUTS

8.2.1 Definition

Life-cycle cost is the total customer cost over the life of a piece of equipment, including purchase cost and operating costs (which are comprised of energy costs, maintenance costs, and repair costs). Future operating costs are discounted to the time of purchase and summed over the lifetime of the equipment. Life-cycle cost is defined by the following equation:

$$LCC = IC + \sum_{t=1}^{N} OC_t / (1+r)^t \qquad \textbf{Eq. 8.1}$$

where:

LCC = life-cycle cost ($),
IC = total installed cost ($),
∑ = sum over the lifetime, from year 1 to year N,
where N = lifetime of equipment (years),
OC = operating cost ($),
r = discount rate, and
t = year for which operating cost is being determined.

Because DOE gathered most of its data for the LCC analysis in 2007, DOE expresses all the costs in 2007$. Total installed cost, operating cost, lifetime, and discount rate are discussed in the following sections. In the LCC analysis, the year of equipment purchase is assumed to be 2012, the effective date of the amended energy conservation standards for PTACs and PTHPs.

8.2.2 Total Installed Cost Inputs

The total installed cost to the customer is defined by the following equation:

$$IC = EQP + INST \qquad \textbf{Eq. 8.2}$$

where:

EQP = equipment price ($) (i.e., customer price for the equipment only),
INST = installation cost or the customer price to install equipment ($) (i.e., the cost for labor and materials).

The equipment price is based on the distribution channel through which the customer purchases the equipment. As discussed in Chapter 6, Markups for Equipment Price Determination, DOE defined four types of distribution channels to describe how the equipment passes from the manufacturer to the customer: (1) the manufacturer sells directly to the customer through a national account, (2) the manufacturer sells the equipment to a wholesaler, who in turn, sells it directly to the customer; (3) the manufacturer sells the equipment to a wholesaler, who sells to a mechanical contractor, who makes the purchase on behalf of the customer, (4) the manufacturer sells the equipment to a wholesaler, who sells to a mechanical contractor hired by a general contractor. The general contractor purchases and install the equipment on behalf of the customer and adds its markup to the mechanical contractor's price.

The remainder of this section provides information about the variables DOE used to calculate the total installed cost for PTAC and PTHP. Inputs to determine total installed cost are shown below:

- Baseline manufacturer selling prices ($) (section 8.2.2.1)
- Standard-level manufacturer selling price increases ($) (section 8.2.2.2)
- Overall markups (section 8.2.2.3)
- Installation costs ($) (section 8.2.2.4)
- Weighted-average total installed costs ($) (section 8.2.2.5)

8.2.2.1 Baseline Manufacturer Selling Price

The baseline MSP is the price charged by manufacturers to either a wholesaler or very large customer for equipment meeting existing minimum efficiency (or baseline) standards. The MSP includes a markup that converts the cost to manufacture (i.e., the manufacturing cost) to a MSP. DOE developed the baseline MSP through an efficiency level analysis supplemented by certain design-option considerations. Refer to Chapter 5, Engineering Analysis, for details. DOE developed MSP for six representative equipment categories within the four equipment classes identified in market and technology assessment analysis, Chapter 3 of the TSD. The LCC and PBP were calculated based on the same set of six representative equipment categories as given in Table 8.2.1.

Table 8.2.1 Representative PTAC and PTHP Equipment Evaluated for the Life-Cycle Cost and Payback Analyses

Equipment Class	Representative Equipment Category	Description
PTAC (Standard Size)	PTAC 9000	Packaged Terminal Air Conditioner, Standard Size, 9,000 Btu/h Cooling Capacity
PTAC (Standard Size)	PTAC 12000	Packaged Terminal Air Conditioner, Standard Size, 12,000 Btu/h Cooling Capacity
PTHP (Standard Size)	PTHP 9000	Packaged Terminal Heat Pump, Standard Size, 9,000 Btu/h Cooling Capacity
PTHP (Standard Size)	PTHP 12000	Packaged Terminal Heat Pump, Standard Size , 12,000 Btu/h Cooling Capacity
PTAC (Non-Standard Size)	PTAC 11000	Packaged Terminal Air Conditioner, Non-Standard Size, 11,000 Btu/h Cooling Capacity
PTHP (Non-Standard Size)	PTHP 11000	Packaged Terminal Heat Pump, Non-Standard Size, 11,000 Btu/h Cooling Capacity

DOE determined the minimum efficiency levels listed in ASHRAE/IESNA Standard 90.1-1999 as the baseline efficiency levels for PTACs and PTHPs. The minimum efficiency levels specified by ASHRAE/IESNA Standard 90.1-1999 are detailed in Chapter 5, Engineering Analysis. DOE developed the MSP for the baseline efficiency equipment as a part of the engineering analysis (see Chapter 5 of the TSD), which are shown in Table 8.2.2.

Table 8.2.2 Baseline Manufacturer Selling Prices per Unit

Representative Equipment	ASHRAE/ IESNA Standard 90.1-1999[5] (Baseline Efficiency)	Baseline Manufacturer Selling Price* (2007$)
PTAC 9000	EER 10.6	$509.76
PTAC 12000	EER 9.9	$608.99
PTHP 9000	EER 10.4, COP 3.0	$568.00
PTHP 12000	EER 9.7, COP 2.9	$665.80
PTAC 11000	EER 8.6	$679.06
PTHP 11000	EER 8.5, COP 2.6	$742.06

* Baseline MSP is based upon the PTAC and PTHP equipping using R-410A refrigerant.

8.2.2.2 Standard-Compliant Manufacturer Selling Price Increases

The standard-compliant MSP increase is the change in MSP associated with producing equipment at higher efficiency levels. DOE developed MSP increases associated with increases in equipment efficiency levels through a combination of efficiency level and design-option analyses in the engineering analysis (see Chapter 5 of the TSD). MSP increases as a function of equipment efficiency were developed for each of the six representative equipment categories in the engineering analysis as well. Table 8.2.3 summarizes the estimated MSP increases for PTAC and PTHP efficiency levels considered in the LCC and PBP analyses.

Table 8.2.3 Standard-compliant Manufacturer Selling Price Increases per Unit (Price Increases Relative to the Price of Baseline Efficiency Equipment)

Representative Equipment	Standard-Compliant MSP (2007$)			
	Efficiency Level 1	Efficiency Level 2	Efficiency Level 3	Efficiency Level 4
PTAC 9000	$10.10	$17.29	$24.86	$32.80
PTAC 12000	$12.71	$21.95	$31.81	$42.30
PTHP 9000	$16.36	$23.55	$31.12	$39.06
PTHP 12000	$20.40	$29.64	$39.50	$49.99
PTAC 11000	$18.03	$27.54	$38.55	#N/A
PTHP 11000	$19.53	$29.04	$40.05	#N/A

8.2.2.3 Overall Markup

For a given distribution channel, the overall markup is the value determined by multiplying all the associated markups and the applicable sales tax together to arrive at a single overall distribution chain markup value. The overall markup is multiplied by the baseline or standard-compliant manufacturing selling price to arrive at the price paid by the customer. Because there are baseline and incremental markups associated with the wholesaler and mechanical contractor, the overall markup is also divided into a baseline markup (i.e., a markup used to convert the baseline manufacturer price into a customer price) and an incremental markup (i.e., a markup used to convert a standard-compliant MSP increase due to an efficiency increase into an incremental customer price). Further, the overall markups are based on distribution channels, as well as whether the equipment is being purchased for a new construction installation or for an existing equipment replacement. As a result, DOE developed the overall baseline markups and incremental markups for both the new construction and replacement applications as a part of the markups analysis (Chapter 6 of the TSD).

Based on the percentages of the market attributed to each of the four distribution channels and whether the equipment goes into replacement applications or new construction applications, the weighted-average overall markups and their associated components are presented in Table 8.2.4 and Table 8.2.5 for the baseline and incremental markups, respectively. The differences between national average incremental markups for standard size and non-standard size units are small enough that the last columns in Table 8.2.5 are identical.

Table 8.2.4 Overall Baseline Markups by Equipment Type

Equipment Type	Replacement Application	New Construction Application	Overall Weighted Average
PTACs and PTHPS (Standard Size)	1.86	2.01	1.89
PTACs and PTHPS (Non-Standard Size)	1.86	2.01	1.93

Table 8.2.5 Overall Incremental Markups by Equipment Type

Equipment Type	Replacement Application	New Construction Application	Overall Weighted Average
PTACs and PTHPS (Standard Size)	1.28	1.29	1.28
PTACs and PTHPS (Non-Standard Size)	1.28	1.29	1.28

8.2.2.4 Installation Cost

The installation cost is the price to the customer of labor and materials (other than the actual equipment) needed to install the PTAC and PTHP equipment. DOE derived installation cost for PTAC and PTHP equipment from data in the *RS Means: Cost Works 2008*. *RS Means* provides estimates on the person-hours required to install PTAC and PTHP equipment and the labor rates associated with the type of crew required to install the equipment[6]. Generally speaking, installation involves movement into the building, installation or setting of equipment (including sleeve), connecting to power supply, filling/flushing/cleaning/touchup, startup and running adjustments, training the owner's representative, and warranty and call-back service. The installation cost was calculated by multiplying the number of person-hours by the corresponding labor rate. *RS Means* provides specific person-hour and labor rate data for the installation of PTAC and PTHP equipment (equipment category 238113). Labor rates vary significantly from region to region of the country and the *RS Means* data provide the necessary information to capture this regional variability. *RS Means* provides cost indices that reflect the labor rates for 295 cities in the United States. Several cities in all 50 States and the District of Columbia are identified in the *RS Means* data. DOE incorporated these cost indices into the analysis to capture variation in installation cost, depending on the location of the customer.

Table 8.2.6 summarizes the nationally representative person-hours and labor rates associated with the installation of PTAC and PTHP equipment as presented in *RS Means*. In Table 8.2.6, both bare installation costs (i.e., costs before overhead and profit [O&P]) and installation costs including O&P are provided. DOE assumed that the installation costs that include O&P represent the installation costs for baseline equipment. These installation costs are assumed to remain fixed regardless of efficiency level (a "flat" installation cost scenario). However, the LCC spreadsheet allows for an alternative scenario - that the installation cost increases with higher efficiency levels - and this alternative was implemented in the LCC spreadsheet by providing for an installation price that varies in proportion to increased manufacturer cost above the baseline efficiency level. DOE did not, however, find a basis for the latter assumption.

Table 8.2.6 Installation Costs for Baseline PTAC and PTHP Equipment

Equipment Type	Person-Hours	Labor Plus O&P (2007$)	
		Rate	Cost
PTAC and PTHP 9000	3.2	$63.76	$204.03
PTAC and PTHP 11000 and 12000	4.0	$63.76	$255.04

Table 8.2.7 summarizes the cost indices for installations in each of the 50 states, plus the District of Columbia, used to vary the nationally representative installation costs in Table 8.2.6. To arrive at an average index for each state, DOE weighted the city indices in each state by their population within the state. DOE used population weights for the year 2007 from the U.S. Census Bureau to calculate a weighted-average index for each state from the R.S. Means data.

Table 8.2.7 Installation Cost Indices (National Average Value = 100.0)

State	Index	State	Index	State	Index
Alabama	63.1	Kentucky	84.2	North Dakota	64.2
Alaska	107.2	Louisiana	62.7	Ohio	101.4
Arizona	79.1	Maine	75.3	Oklahoma	61.5
Arkansas	62.0	Maryland	93.9	Oregon	114.0
California	126.5	Massachusetts	123.5	Pennsylvania	122.9
Colorado	86.0	Michigan	107.0	Rhode Island	118.2
Connecticut	126.6	Minnesota	122.4	South Carolina	45.2
Delaware	125.3	Mississippi	60.0	South Dakota	39.9
Dist. of Columbia	99.6	Missouri	105.6	Tennessee	71.2
Florida	67.9	Montana	77.4	Texas	63.6
Georgia	73.9	Nebraska	88.1	Utah	144.6
Hawaii	119.5	Nevada	142.5	Vermont	70.0
Idaho	76.8	New Hampshire	91.9	Virginia	74.4
Illinois	137.6	New Jersey	132.7	Washington	108.0
Indiana	88.9	New Mexico	74.9	West Virginia	91.3
Iowa	81.3	New York	171.9	Wisconsin	103.9
Kansas	72.4	North Carolina	45.3	Wyoming	64.4

8.2.2.5 Weighted-Average Total Installed Cost

As presented in Eq.8.2, the total installed cost is the sum of the equipment price and the installation cost. DOE derived the customer equipment price for any given efficiency level by multiplying the baseline MSP by the baseline markup and adding to it the product of the incremental MSP and the incremental markup. Because MSPs, markups, and the sales tax all can take on a variety of values, depending on location, the resulting total installed cost for a particular efficiency level will not be a single-point value, but rather a distribution of values.

The baseline MSP and the standard-compliant MSP increases are the starting points for determining the total installed cost (values are taken directly from Table 8.2.2 and Table 8.2.3). DOE used the baseline and incremental markups and installation costs to convert the MSPs into total installed costs for a case where the incremental installation costs are held flat. As an example, the weighted average costs for the PTAC 9,000 equipment category are presented for the baseline level. Table 8.2.8 summarizes the weighted-average costs and markups necessary for determining the weighted-average baseline and standard-compliant total installed costs.

Table 8.2.8 Costs and Markups for Determination of Weighted-Average Total Installed Costs (PTAC 9,000)*

Variable	Weighted Average or Mean Value
Baseline Manufacturer selling price	$509.76
Standard-compliant Manufacturer selling price Increase (Efficiency Level 4)	$32.80
Overall Baseline Markup - Standard Size	1.886
Overall Incremental Markup – Standard Size	1.281
Installation Cost–Baseline	$204.00
Installation Cost Factor –Incremental	1.00**

* Incremental installation costs held flat
** National incremental cost index on a population-weighted national basis is equal to 1.00.

To illustrate the derivation of the weighted-average total installed cost shown in Table 8.2.8, DOE presents the calculation below for the baseline efficiency and a higher efficiency (efficiency level 4) standard size PTAC with cooling capacity of 9,000 Btu/h unit (PTAC 9000). For baseline equipment, the calculation of the total installed cost at national average conditions is as follows:

$$IC_{BASE\ PTAC\ 9000} = EQP_{BASE-\ PTAC\ 9000} + INST_{BASE-\ PTAC\ 9000} \times INSTNDEX \qquad \textbf{Eq. 8.3}$$

$$\begin{aligned}
&= MSP_{BASE-\ PTAC\ 9000} \times MU_{BASE-\ PTAC\ 9000} + INST_{BASE-PTAC\ 9000} \times INSTNDEX \\
&= \$509.76 \times 1.886 + \$204 \times 1.00 \\
&= \$963.45 + \$204.00 \\
&= \$1165
\end{aligned}$$

where

IC	= total installed cost ($),
EQP	= equipment price ($),
MSP	= manufacturer selling price ($),
MU	= overall baseline markup,
INST	= installation cost or the customer price to install equipment ($),
INSTINDEX	= location dependent installation cost index, approximately 1.0 at a national average.

In this specific example, *MSP* is the national average baseline MSP for the PTAC 9000 equipment class and *MU* is the overall baseline markup factor. The calculation of the higher efficiency (efficiency level 4) total installed cost includes the use of a MSP adder. In addition, DOE derived an incremental markup.

Based on incremental equipment price changes, the derivation of the efficiency level 4 total installed cost is based on determining the change in equipment price over the baseline equipment price. The manufacturer price increment for higher efficiency equipment is multiplied by the incremental markup.

DOE calculated the efficiency level 4 total installed cost ($IC_{PTAC\ 9000\ TSL4}$) as follows:

$$IC_{PTAC\ 9000\ TSL4} = (EQP_{BASE\text{-}PTAC\ 9000} + \Delta EQP_{PTAC\ 9000\ TSL4}) + INST_{PTAC\ 9000\ TSL4} \times INSTINDEX \qquad \textbf{Eq. 8.4}$$

$$\begin{aligned} &= (MSP_{BASE\text{-}PTAC\ 9000} \times MU_{BASE\ PTAC\ 9000}) + (\Delta MSP_{PTAC\ 9000\ TSL4} \\ &\quad \times MU_{PTAC\ 9000\ TSL4}) + INST_{PTAC\ 9000\ TSL4} \times ISTINDEX \\ &= \$509.76 \times 1.886 + \$32.80 \times 1.281 + \$204 \times 1.00 \\ &= \$1207 \end{aligned}$$

where

ΔEQP	= increase in equipment price ($),
ΔMFG	= increase in manufacturer price ($),
MU	= markup factor (base or incremental, as shown in Table 8.2.4 and Table 8.2.5, respectively)

Table 8.2.9 presents the average equipment price, installation costs, and total installed costs for the representative equipment PTAC 9000 at the baseline level and each efficiency level examined.

Table 8.2.9 Manufacturer Price, Equipment Price, Installation Cost, and Total Installed Costs for PTAC 9000, at U.S. Average Prices (2007$)*

Efficiency Level	Manufacturer Selling Price	Equipment Price (Including Markups)	Installation Cost	Total Installed Cost
Baseline (ASHRAE 90.1-1999)	$510	$961	$204	$1,165
Level 1	$520	$974	$204	$1,178
Level 2	$527	$984	$204	$1,188
Level 3	$535	$993	$204	$1,197
Level 4	$543	$1,003	$204	$1,208

* Details may not add to total due to rounding.

8.2.3 Operating Cost Inputs

DOE based the operating cost for the LCC analysis on energy consumption data developed from whole-building simulations on a representative hotel and model building prototype. After the LCC analysis was performed, DOE generated a distribution of LCC differences (i.e., the LCC difference between the baseline equipment and equipment with a higher efficiency level) to determine the mean LCC difference, as well as the percentage of customers analyzed that had LCC savings associated with more energy-efficient equipment.

DOE defined the operating cost by the following equation:

$$OC = EC + RC + MC \qquad \textbf{Eq. 8.5}$$

where

OC = operating cost ($),
EC = energy cost associated with operating the equipment ($),
RC = repair cost associated with component failure ($),
MC = annual maintenance cost for maintaining equipment operation ($).

The remainder of this section provides information about the variables that DOE used to calculate the operating cost for PTAC and PTHP equipment. Equipment lifetime, discount rate, and effective date of the amended energy conservation standard are required for determining the operating cost and for establishing the operating cost present value. The energy consumption per unit for the baseline efficiency and standard-compliant cases (efficiency level 1, 2, etc.), combined with the electricity prices, are used to determine the annual energy costs of the equipment. Chapter 7, Building Energy Use Characterization Analysis, provides complete details on the PTAC and PTHP equipment energy consumption results for all 50 states and the District of Columbia. The key inputs for the determination of operating costs are shown below:

- Baseline and standard-compliant annual energy consumption (kWh) (Chapter 7)
- Electricity price (cents/kWh) (section 8.2.3.1)
- Electricity price trend (section 8.2.3.2)
- Repair cost ($) (section 8.1.1.1)

- Maintenance cost ($) (section 8.2.3.4)
- Equipment lifetime (years) (section 8.2.3.5)
- Discount rate (percentage) (section 8.2.3.6)
- Effective date of amended energy conservation standard (section 8.2.3.7)

8.2.3.1 Electricity Price Analysis

Introduction to the analysis of electricity prices. This section describes the electricity price (cents/kWh) analysis used to develop the energy portion of the annual operating costs (i.e., electricity price times electricity consumption) for PTACs and PTHPs in the four types of businesses analyzed.

Subdivision of the Country. Because of the wide variation in electricity consumption patterns, wholesale costs, and retail rates across the country, it is important to consider regional differences in electricity prices. For this reason, DOE divided the continental U.S. into the 50 states and the District of Columbia. DOE used reported average effective commercial electricity prices at the state level from Energy Information Administration (EIA) data for 2007.[1] The latest available prices from this source were for the calendar year 2007. Table 8.2.10 provides data on the adjusted electricity prices.

Table 8.2.10 Estimated Commercial Electricity Prices by State (2007 cents/kWh)

State	Commercial Electricity Price	State	Commercial Electricity Price	State	Commercial Electricity Price
Alabama	8.70	Kentucky	6.65	North Dakota	6.53
Alaska	11.93	Louisiana	9.17	Ohio	8.63
Arizona	8.25	Maine	13.12	Oklahoma	7.30
Arkansas	6.88	Maryland	11.51	Oregon	7.23
California	12.76	Massachusetts	15.12	Pennsylvania	9.18
Colorado	7.60	Michigan	8.95	Rhode Island	12.78
Connecticut	15.26	Minnesota	7.39	South Carolina	7.73
Delaware	11.22	Mississippi	8.95	South Dakota	6.54
Dist. of Col.	12.32	Missouri	6.25	Tennessee	7.99
Florida	9.69	Montana	7.95	Texas	10.00
Georgia	8.04	Nebraska	6.28	Utah	6.54
Hawaii	21.92	Nevada	10.10	Vermont	12.25
Idaho	5.13	New Hampshire	13.83	Virginia	6.40
Illinois	9.14	New Jersey	13.26	Washington	6.55
Indiana	7.20	New Mexico	7.64	West Virginia	5.78
Iowa	7.06	New York	15.44	Wisconsin	8.61
Kansas	6.90	North Carolina	7.41	Wyoming	6.20

Furthermore, DOE recognized that different kinds of businesses typically use electricity in different amounts at different times of the day, week, and year, and therefore face different effective prices. To make this adjustment, DOE used EIA's 2003 CBECS data set to identify the average prices paid by the four kinds of businesses in this analysis compared with the average prices paid by all commercial customers[2]. Equation 8.7 shows the ratio of prices paid by the four types of businesses used to increase or decrease the average electricity prices for commercial buildings.

$$EPRICE_{COM\ BLD\ I\ STATE\ 2007} = EPRICE_{COM\ STATE\ 2007} \text{ x } (EPRICE_{BLDG\ I\ US\ 2003}/EPRICE_{COM\ US\ 2003}) \qquad \textbf{Eq. 8.7}$$

where

$EPRICE_{COM\ BLD\ I\ STATE\ 2007}$ = average commercial sector electricity price in building type I (large chain hotel/motel) in a specific state in 2007,

$EPRICE_{COM\ STATE\ 2007}$ = average commercial sector electricity price in a specific state in 2007,

$EPRICE_{BLDG\ I\ US\ 2003}$ = national average commercial sector electricity price in building type I in 2003 CBECS,

$EPRICE_{COM\ US\ 2003}$ = national average commercial sector electricity price in 2003 CBECS.

Table 8.2.11 shows the derivation of the *EPRICE* ratios from 2003 CBECS data set.

Table 8.2.11 Derived Average Commercial Electricity Price Ratios by Business Type

Business Type	Large Chain Hotel/Motel	Independent Hotel	Health Care (Assisted Living and Nursing Homes)	Office	All Commercial Buildings
Electricity Price (cents/kWh)	8.4	8.4	Insufficient data	9.9	7.8
Ratio of Electricity Price to Average Price for all Commercial Buildings	1.083	1.083	1.00	1.276	1.00

Source: CBECS 2003

Once the electricity prices for the four types of building businesses were adjusted, DOE used the resulting prices in the analysis to represent 2007 electricity prices. To obtain a weighted-average national price, DOE weighted the prices paid by each business in each state by the estimated sales of PTAC and PTHP units in each state to each type of business. The state/building type weights are the probabilities that a given PTAC or PTHP unit shipped will be operated with a given price. For evaluation purposes, the prices and weights can be depicted as a cumulative probability distribution. The effective prices (2007$) range from approximately 5.1 cents per kWh to approximately 28.0 cents per kWh. Figure 8.2.1 illustrates the results for PTACs and PTHPs in all four business types and all states. (The display range on the chart reaches only to 23.7 cents/kWh although the true maximum is 28.0 cents.)

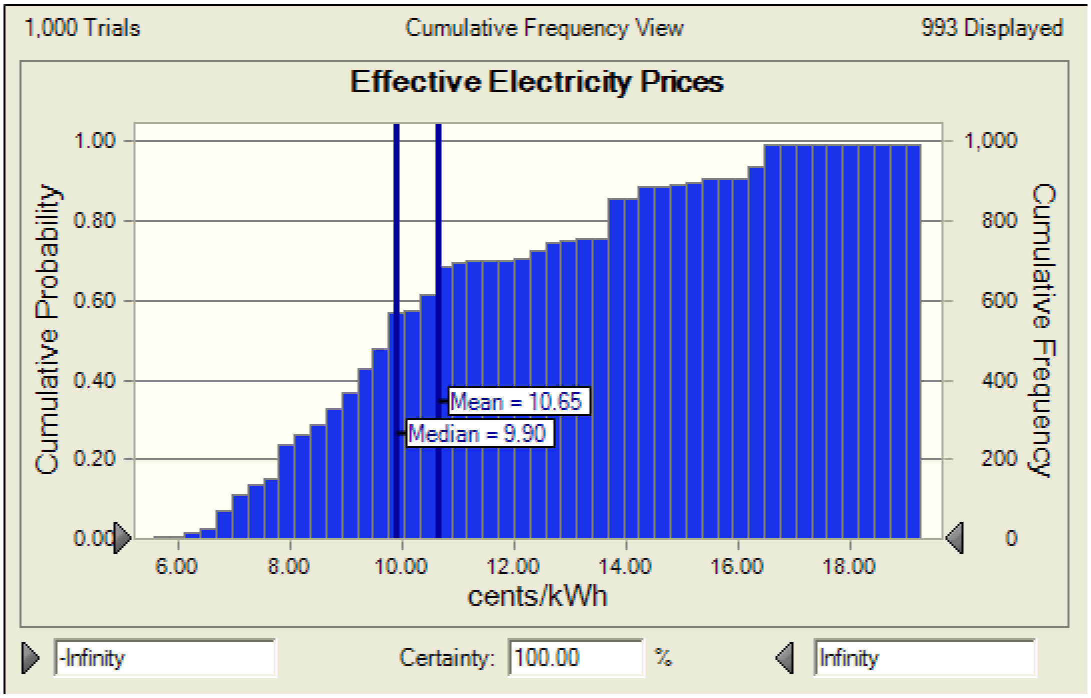

Figure 8.2.1 Cumulative Probability Distribution Showing the Estimated Electricity Prices Paid by PTAC and PTHP Customers (2007$)

8.2.3.2 Electricity Price Trend

The electricity price trend provides the relative change in electricity prices for future years out to the year 2042. Estimating future electricity prices is difficult, especially considering that there are efforts in many states throughout the country to restructure the electricity supply industry.

DOE applies a projected trend in national average electricity prices to each customer's energy prices. The discussion in this chapter uses the *AEO 2008* reference price scenario. In the LCC analysis, the following four scenarios can be analyzed:

1. Constant energy prices at 2007 values (Constant index of 1.0 in Figure 8.2.2)
2. *AEO 2008*, High Economic Growth ("High" in Figure 8.2.2)
3. *AEO 2008*, Reference Case ("AEO 2008" in Figure 8.2.2)
4. *AEO 2008*, Low Economic Growth ("Low" in Figure 8.2.2)

Figure 8.2.2 shows the trends for the three *AEO 2008* price projections where prices are assumed to change. DOE extrapolated the values in later years (i.e., after 2030) from their relative sources because *AEO 2008* does not forecast beyond 2030. To arrive at values for these later years, DOE used the price trend from 2020 to 2030 of the forecast to establish prices in the years 2030 to 2042. This method of extrapolation is in line with methods currently used by the EIA to forecast fuel prices for the Federal Energy Management Program.

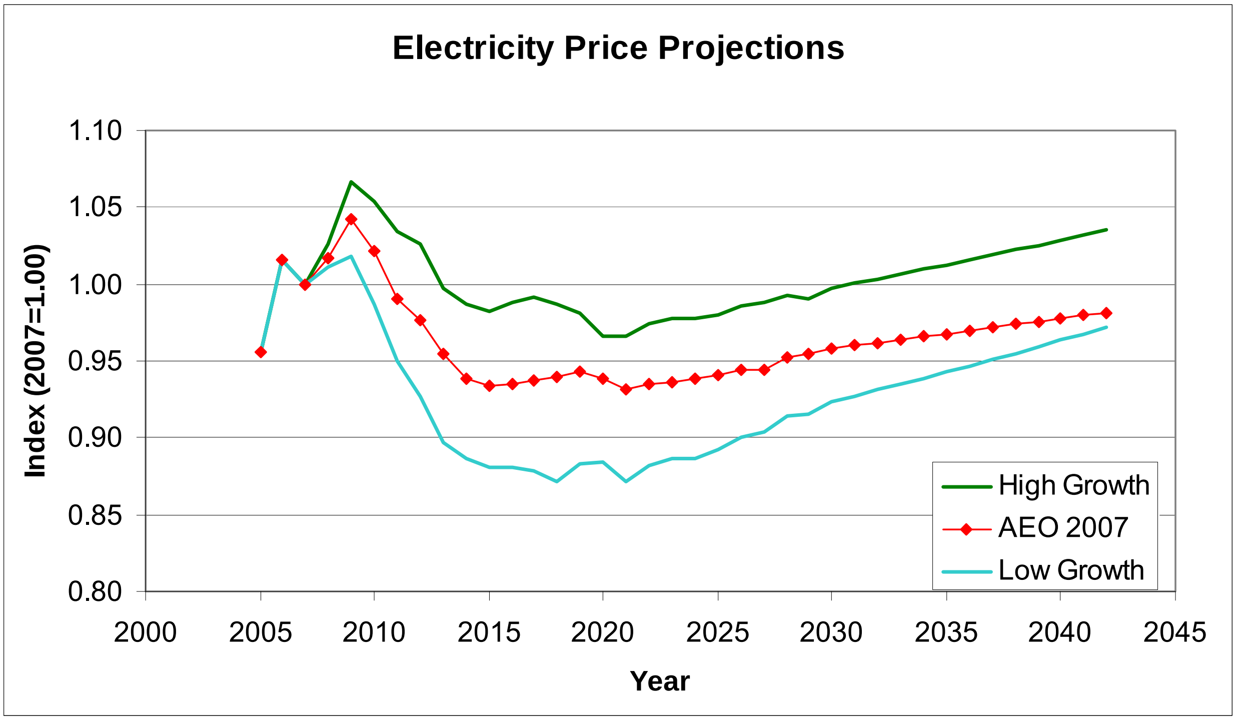

Figure 8.2.2 Electricity Price Trends for Commercial Rates to 2042

The default electricity price trend scenario used in the LCC analysis is the trend from the *AEO 2008* Reference Case, which is the middle line in Figure 8.2.2. Spreadsheets used in calculating the LCC have the capability to analyze the other electricity price trend scenarios, namely, the *AEO 2008* High Growth and the *AEO 2008* Low Growth price trends and constant energy prices.[a]

[a] EIA did not publish its high- and low-growth forecasts in time for incorporation into this final rule, DOE developed high- and low-growth electricity forecasts corresponding to the AEO 2008 forecasts. DOE calculated the ratio of the AEO 2007 high- or low-growth forecasted electricity price to the AEO 2007 reference case forecast for each year. DOE then applied those ratios, respectively, to the AEO 2008 reference case prices. Subsequent examination of the actual AEO 2008 high and low price indices shows them to be 0%-3% higher in the short run and 4%-7% lower in the long run than the calculated values used in the analysis.

8.2.3.3 Repair Cost

The repair cost is the cost to the customer for replacing or repairing components in the PTAC and PTHP equipment that have failed. DOE based the annualized repair cost for baseline efficiency equipment (i.e., the cost the customer pays annually for repairing the equipment) on the following expression:

$$RC = W \times ANNFAC \qquad \textbf{Eq. 8.8}$$

where

RC	= repair cost ($),
W	= purchase cost for a warranty contract ($),
ANNFAC	= annualization factor.

DOE estimated annualized maintenance costs for PTACs and PTHPs from data in a Carrier corporate website, which provides costs to purchase an extended warranty agreement.[7] The warranty covers for either 5 years ($55) or 7 years ($99). The equivalent annualized cost of these contracts varied slightly, depending on the discount rate used in the annualization factor, but the average cost was $12.89 for the 5-year contact and $17.44 for the 7-year contract at the discount rate of 5.53 percent, the average discount rate for the dominant group of purchasers. The average of these two values is $15.17, the value used in the analysis.

Because data were not available to indicate how repair costs vary with equipment efficiency level, DOE considered two scenarios: (1) repair costs vary in direct proportion with the MSP of the equipment and (2) repair costs remain constant (i.e., did not increase due to a higher efficiency).

DOE used repair costs that increase with MSP (the first scenario above) as the default annualized repair cost scenario in the LCC and PBP analysis. Spreadsheets used to calculate the LCC and PBP are able to calculate LCC and PBP based on the second scenario as well.

8.2.3.4 Maintenance Cost

The maintenance cost is the cost to the customer of maintaining equipment operation. The maintenance cost is not the cost associated with the replacement or repair of components that have failed (as discussed above). Rather, it is the cost associated with general maintenance (e.g., cleaning coils and drain pan, changing air filters, etc.).

Virtually no data are available on annual maintenance cost per unit. DOE estimated annual routine maintenance costs for PTAC and PTHP equipment at $117 per year per unit from data in *RS Means Costworks* on annual preventative maintenance of air source heat pumps up to 5 tons in capacity.

Because data were not available to indicate how maintenance costs vary with equipment efficiency, DOE decided to use preventative maintenance costs that remain constant as equipment efficiency is increased.

8.2.3.5 Equipment Lifetime

DOE defines equipment lifetime as the age when a PTAC or PTHP unit is retired from service. DOE reviewed available literature and consulted with manufacturers in order to establish typical equipment lifetimes. The literature and experts consulted offered a wide range of typical equipment lifetimes. Individuals with previous experience in manufacturing or distribution of PTACs and PTHPs suggested a typical lifetime of 5 to 15 years. Some experts suggested that the lifetime could be even lower because of the daily or continuous use of the equipment and neglect of maintenance such as cleaning the heat exchangers or replacing the air filters. Previously, DOE used a 15-year lifetime for PTACs and PTHPs in the 2000 Screening Analysis[a] based on data from ASHRAE's 1995 Handbook of HVAC Applications. Stakeholders commented on the 2000 Screening Analysis and suggested DOE use the 10-year lifetime assumption rather than 15-year lifetime to more accurately reflect the life and usage characteristics of this equipment. Therefore, based on the information it gathered, DOE concluded that a typical lifetime of 10 years is appropriate for PTAC and PTHP equipment. Furthermore, DOE modeled the lifetime of PTAC and PTHP equipment as a Weibull statistical distribution with an average lifetime of 10 years and a maximum lifetime of 20 years. Chapter 3 of the TSD contains a discussion of equipment lifetime,

8.2.3.6 Discount Rate

The discount rate is the rate at which future expenditures are discounted to establish their present value. DOE derived the discount rates for the LCC analysis by estimating the cost of capital for companies that purchase PTAC and PTHP equipment. The cost of capital is commonly used to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so their cost of capital is the weighted average of the cost to the company of equity and debt financing.

DOE estimated the cost of equity financing by using the Capital Asset Pricing Model (CAPM).[8] The CAPM, among the most widely used models to estimate the cost of equity financing, assumes that the cost of equity is proportional to the amount of systematic risk associated with a company. The cost of equity financing tends to be high when a company faces a large degree of systematic risk and it tends to be low when the company faces a small degree of systematic risk.

DOE determined the cost of equity financing by using several variables, including the risk coefficient of a company, β(beta), the expected return on "risk free" assets (R_f), and the additional return expected on assets facing average market risk, also known as the equity risk premium or *ERP*. The risk coefficient of a company, β, indicates the degree of risk associated

[a] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. "Energy Conservation Program for Consumer Products: Screening Analysis for EPACT-Covered Commercial HVAC and Water-Heating Equipment Screening Analysis." April 2000.

with a given firm relative to the level of risk (or price variability) in the overall stock market. Risk coefficients usually vary between 0.5 and 2.0. A company with a risk coefficient of 0.5 faces half the risk of other stocks in the market; a company with a risk coefficient of 2.0 faces twice the overall stock market risk.

The following equation gives the cost of equity financing for a particular company:

$$k_e = R_f + (\beta \cdot ERP) \qquad \textbf{Eq. 8.9}$$

where

k_e = the cost of equity for a company (%),
R_f = the expected return of the risk free asset (%),
β =the risk coefficient,
ERP = the expected equity risk premium (%).

DOE defined the risk free rate (R_f) as the yield in January 2008 on long-term government bonds. DOE used a rate (k_e) that varies with the *ERP*, based on data from the Damodaran Online site.[1]

The cost of debt financing is the yield or interest rate paid on money borrowed by a company (for example, by selling bonds). As defined here, the cost of debt includes compensation for default risk (the risk that a firm will go bankrupt) and excludes deductions for taxes. DOE estimated the cost of debt for companies by adding a risk adjustment factor to the current yield on long term corporate bonds (the risk free rate). It used this procedure to estimate current (and future) company costs to obtain debt financing. It based the adjustment factor on indicators of company risk, such as credit rating or variability of stock returns.

The weighted-average cost of capital (WACC) of a company is the weighted-average cost of debt and equity financing:

$$k_r = (k_e \cdot w_e + k_d \cdot w_d)/(1+r) \qquad \textbf{Eq. 8.10}$$

where

k_r = the (real) weighted-average cost of capital (%),
k_e = the expected rate of return on equity (%),
k_d = the expected rate of return on debt (%),
w_e = the proportion of equity financing in total annual financing,
w_d = the proportion of debt financing in total annual financing,
r = the expected inflation rate (%).

The weighted-average cost of capital is a real rate, because it excludes anticipated future inflation in the expected returns from stocks and bonds. DOE calculated expected inflation (2.0 percent) from the average of the projected change in gross domestic product (GDP) prices in the *Economic Report of the President* (February 2008).[9]

To estimate the WACC of PTAC and PTHP equipment purchasers, DOE used a sample of companies involved in large hotel/motel chains drawn from a database of 7,369 U.S.

companies given on the *Damodaran Online* website. This database includes most of the publicly-traded companies in the United States.

DOE divided the companies into the four ownership categories shown in Table 8.2.12 according to their type of activity. DOE sought financial information for all of the firms in the full sample involved in the two lines of business, i.e., the large hotel chain and health care. In cases where one or more of the variables needed to estimate the discount rate was missing or could not be obtained, or where in the hotel/gaming business a firm was clearly engaged only in gaming, DOE discarded the firm from the analysis. This resulted in a sample of 34 firms, 28 in the hotel/gaming business and six in the assisted living business.

Table 8.2.12 describes the economic sectors represented in each of the ownership categories as well as the number of companies used for determining discount rates.

Table 8.2.12 Real Discount Rates by Company and Ownership Category

Company	Company Value (million $)	Value Line Beta	Cost of Equity (E)	E/(D+E)	Std Dev in Stock	Cost of Debt (D)	Effective Tax Rate	After Tax Cost of Debt	Market Debt to Capital (D/(D+E)	Cost of Capital
A	$2,280.80	0.85	8.39%	92.44%	31.94%	5.28%	27.42%	3.83%	7.56%	8.05%
B	$165.20	1.2	10.09%	56.05%	71.48%	6.28%	0.00%	6.28%	43.95%	8.41%
C	$2,462.10	1.1	9.60%	69.31%	28.83%	5.03%	0.00%	5.03%	30.69%	8.20%
D	$14,736.20	1.1	9.60%	60.11%	20.34%	4.78%	1.59%	4.70%	39.89%	7.65%
E	$47.40	0.15	5.01%	21.31%	38.09%	5.28%	0.00%	5.28%	78.69%	5.22%
F	$744.70	1.15	9.85%	65.50%	35.96%	5.28%	22.01%	4.12%	34.50%	7.87%
G	$14,237.60	1	9.12%	87.13%	18.71%	4.53%	28.69%	3.23%	12.87%	8.36%
H	$3,154.40	1.2	10.09%	77.29%	31.59%	5.28%	18.90%	4.28%	22.71%	8.77%
I	$305.50	0.65	7.43%	62.00%	30.17%	5.28%	0.00%	5.28%	38.00%	6.61%
J	$21.90	0.25	5.49%	81.74%	48.53%	5.53%	0.00%	5.53%	18.26%	5.50%
K	$446.00	1.2	10.09%	35.87%	93.65%	6.28%	38.50%	3.86%	64.13%	6.10%
L	$162.80	0.85	8.39%	79.05%	127.59 %	6.28%	0.00%	6.28%	20.95%	7.95%
M	$11,348.30	1.25	10.33%	76.81%	22.30%	4.78%	36.21%	3.05%	23.19%	8.64%
N	$2,553.10	0.9	8.64%	79.19%	24.51%	4.78%	39.00%	2.92%	20.81%	7.45%
O	$14,992.20	1.15	9.85%	84.08%	46.25%	5.53%	0.00%	5.53%	15.92%	9.16%
P	$2,461.80	0.95	8.88%	64.13%	34.25%	5.28%	39.46%	3.20%	35.87%	6.84%
Q	$225.80	0.65	7.43%	66.03%	35.10%	5.28%	0.00%	5.28%	33.97%	6.70%
R	$92.50	0.85	8.39%	100.00%	55.79%	5.78%	0.00%	5.78%	0.00%	8.39%
S	$5.90	0.5	6.70%	66.10%	42.71%	5.53%	0.00%	5.53%	33.90%	6.30%
T	$28,716.40	0.95	8.88%	57.90%	21.75%	4.78%	37.51%	2.99%	42.10%	6.40%
U	$1,848.80	1.35	10.81%	23.30%	35.59%	5.28%	0.00%	5.28%	76.70%	6.57%
V	$37,059.80	1.1	9.60%	64.94%	34.41%	5.28%	39.05%	3.22%	35.06%	7.36%
W	$462.00	1.15	9.85%	100.00%	40.83%	5.53%	34.79%	3.61%	0.00%	9.85%
X	$468.80	1.2	10.09%	40.68%	43.81%	5.53%	54.39%	2.52%	59.32%	5.60%
Y	$2,176.00	1.4	11.06%	64.42%	32.11%	5.28%	39.96%	3.17%	35.58%	8.25%
Z	$3.90	1.25	10.33%	87.18%	194.07 %	6.28%	0.00%	6.28%	12.82%	9.81%
AA	$1.40	0.25	5.49%	100.00%	297.18 %	6.28%	0.00%	6.28%	0.00%	5.49%
AB	$606.90	0.85	8.39%	64.11%	56.92%	5.78%	0.00%	5.78%	35.89%	7.46%

Table 8.2.12 (cont'd)

Company	Company Value	Value Line Beta	Cost of Equity (E)	E/(D+E)	Std Dev in Stock	Cost of Debt (D)	Effective Tax Rate	After Tax Cost of Debt	Market Debt to Capital (D/(D+E))	Cost of Capital
Large Hotel Chain Average	$5,063.86	1.07	9.48%	68.65%	29.20%	5.03%	27.14%	3.68%	31.35%	7.64%
Inflation-Adjusted										**5.53%**
AC	$112.10	1.2	10.09%	57.63%	54.88%	5.78%	0.00%	5.78%	42.37%	8.26%
AD	$1,680.60	0.45	6.46%	57.09%	41.24%	5.53%	0.00%	5.53%	42.91%	6.06%
AE	$1,107.20	1.05	9.36%	88.24%	38.53%	5.28%	39.53%	3.19%	11.76%	8.64%
AF	$343.10	1.3	10.57%	100.00%	26.21%	5.03%	35.40%	3.25%	0.00%	10.57%
AG	$1,533.80	0.95	8.88%	86.78%	24.67%	4.78%	37.13%	3.01%	13.22%	8.10%
AH	$129.40	1.2	10.09%	100.00%	42.19%	5.53%	0.00%	5.53%	0.00%	10.09%
Health Care (Nursing Homes and Assisted Living) Weighted Average	$4,906.20	0.84	8.34%	$0.78	34.73%	$0.05	23.00%	4.06%	22.46%	7.75%
Inflation-Adjusted										**5.64%**
Independent Hotels, Inflation Adjusted										**8.03%**
Office, Inflation Adjusted										**8.14%**

E=equity; D=debt

Source: Pacific Northwest National Laboratory (PNNL) calculations applied to firms sampled from the Damodaran Online website.

Ultimately, DOE used a sample of 34 companies to represent the purchasers of PTAC and PTHP equipment in the large chain component of the hotel industry and the nursing home/assisted living industry. For each company in the sample, DOE derived the cost of debt, percent debt financing, and systematic company risk from information provided at the *Damodaran Online* website. It estimated the cost of debt financing from the long-term government bond rate (4.39 percent) and the standard deviation of the stock price. Table 8.2.12 shows the weighted-average values for the cost of debt, percent debt financing and systematic firm risk for each category of the sample companies. The cost of capital for independent hoteliers, and small office companies with more limited access to capital is more difficult to determine. Individual credit-worthiness varies considerably, and some franchisees have access to the financial resources of the franchising corporation. However, personal contacts with a sample of commercial bankers yielded an estimate for the small operator weighted cost of capital of about 200 to 300 basis points (2 percent to 3 percent) above the rates for larger hotel chains. A central value equal to the weighted average of large hotel chains (7.64 percent), plus 2.5 percent, was used for independent hotel/motels and the same multiplier was applied to large nursing home/assisted care companies (7.75 percent) to derive an estimate for small health care practitioners occupying small office buildings.

Deducting expected inflation from the cost of capital provides the estimates of the real discount rate by ownership category shown in Table 8.2.12. DOE modeled the cost of capital as statistical distributions. Large chain hotels and independent hotels were modeled as normal distributions. Health care facilities and offices costs of capital were modeled as triangular distributions due to small sample size. The average after-tax discount rate, weighted by the percentage shares of total PTAC and PTHP purchases, is 5.53 percent for large hotel chains, 8..03 percent for independent hotels, 5.64 percent for health care (nursing homes and assisted care facilities) and 8.14 percent for offices (medical and dental offices).

8.2.3.7 Effective Date of Amended Energy Conservation Standard

The effective date is the future date when a new or an amended energy conservation standard becomes operative. Under 42 U.S.C. 6313(a)(6)(c), the effective date of any amended energy conservation standard for PTACs and PTHPs will be four years after the final rule is published. DOE calculated the LCC for all customers as if they each would purchase a new PTAC or PTHP unit in the year the amended standard takes effect. Consistent with its published regulatory agenda, DOE assumed that the final rule would be issued in September 2008 and that, therefore, the amended standards would take effect in 2012 and used these dates in the Notice of Proposed Rule (NOPR) analyses. It based the cost of the equipment in 2012; however, all dollar values are expressed in 2007$. DOE considered annual energy prices for the life of the PTAC and PTHP equipment.

8.3 PAYBACK PERIOD INPUTS

8.3.1 Definition

The payback period (PBP) is the amount of time it takes the customer to recover the assumed higher purchase cost of more energy-efficient equipment as a result of lower operating costs. Numerically, the PBP is the ratio of the increase in purchase cost (i.e., from a less efficient design to a more efficient design) to the decrease in annual operating expenditures. This type of calculation is known as a "simple" payback period, because is does not take into account changes in operating cost over time or the time value of money—that is, the calculation is done at an effective discount rate of zero percent.

The equation for PBP is:

$$PBP = \Delta IC / \Delta OC \qquad \textbf{Eq. 8.11}$$

Where

PBP = payback period (years),
ΔIC = difference in the total installed cost between each efficiency level and the baseline efficiency level ($),
ΔOC = difference in annual operating costs between each efficiency level and the baseline efficiency level ($).

Payback periods are expressed in years. Payback periods greater than the life of the equipment mean that the increased total installed cost of the more efficient equipment is not recovered in reduced operating costs over the life of the equipment.

8.3.2 Inputs

The data inputs to PBP are the total installed cost of the equipment to the customer for each efficiency level and the annual (first year) operating costs for each efficiency level. The inputs to the total installed cost are the equipment price and the installation cost. The inputs to the operating costs are the annual energy cost, the annual repair cost, and the annual maintenance cost. The PBP uses the same inputs as the LCC analysis described in section 8.2, except that electricity price trends and discount rates are not required. Since the PBP is a "simple" (undiscounted) payback, the required electricity cost is only for the year in which a new or an amended energy conservation standard is to take effect—in this case, the year 2012. The electricity price used in the PBP calculation was the price projected for 2012. The electricity price used in the PBP calculation of energy cost was the price projected for 2012, expressed in 2007 dollars, but not discounted to 2007. Discount rates are not used in the PBP calculation.

8.4 RESULTS USING AVERAGE ELECTRICITY PRICES

8.4.1 Life-Cycle Cost Results

This section presents LCC results for the higher efficiency levels and also presented in section 8.2.2.2, Standard-Compliant Manufacturer Selling Price Increases. The results presented here are based on annual operating costs calculated from average annual electricity prices developed for each business type. Section 8.2 presents the electricity price inputs as well as all other LCC inputs.

Because the values of most inputs are variable in this analysis, DOE represents them as a distribution of values rather than a single point-value. Thus, DOE represents the LCC results as a distribution of values. Before proceeding with the presentation of the distribution of LCC results, DOE presents average values for total installed costs, annual operating costs, and LCC to show how these costs vary with efficiency level for each of the PTAC and PTHP equipment classes.

8.4.1.1 Life-Cycle Cost Breakdown Based on Average Input Values

Figure 8.4.1 shows how, on an average basis, the total installed costs, annual operating costs, and LCC vary with efficiency level for the standard size PTAC with a cooling capacity of 9,000 Btu/h for large chain hotels. Level 0 in Figure 8.4.1 refers to the baseline efficiency level. Similar figures for other equipment classes are provided in appendix E.

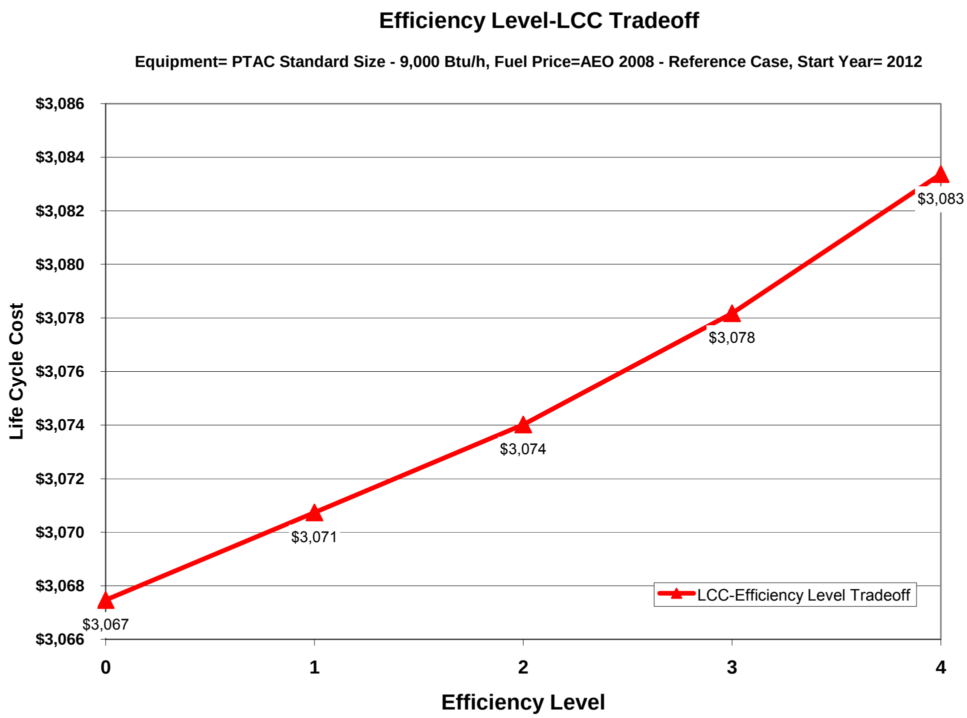

Figure 8.4.1 Effect of the Change in Efficiency Level on Life-Cycle Cost for Standard Size PTAC with a Cooling Capacity of 9,000 Btu/h in Large Chain Hotels (2007$) at Average U.S. Conditions (Level 0 is the Baseline Efficiency Level) REVISE CHART

Annual energy cost is the largest contributor to the overall operating cost at any efficiency level. As efficiency level is increased, annual energy cost decreases.

The LCC results reveal that as efficiency is increased, the lifetime operating cost has less of an impact on the LCC than the total installed cost. In other words, the increase in total installed cost offsets the decrease in lifetime operating costs that occurs with an increase in equipment efficiency. As a result, the LCC at all trial standard levels is higher than that for the baseline level (Level 0).

Again, the results shown in Figure 8.4.1 are based on average input values rather than input distributions and are depicted for only one building type. Thus, one can observe how the various inputs impact LCC and, in turn, how the resulting LCC changes with an increase in efficiency level in this example. Conclusions, however, should also take into account the distribution of LCC results presented in section 8.4.1.2.

8.4.1.2 Differences in LCC between Baseline and Standard-compliant Equipment

DOE's first step in developing LCC results was to establish the baseline LCC for each of the PTAC and PTHP equipment classes. As discussed in section 8.2.2.1, the baseline efficiency level for the NOPR analysis is the minimum efficiency level specified by ASHRAE/IESNA Standard 90.1-1999 for a given equipment class of PTAC and PTHP equipment.

This section presents the differences in the LCC of standard-compliant equipment relative to the baseline efficiency equipment. The LCC differences are depicted as a distribution of values. DOE presents the results in a chart showing the cumulative distribution of LCC differences along with the corresponding probability of occurrence for each efficiency level. In each chart, DOE provides the mean LCC difference along with the percent of the installations for which the LCC will decrease (the percent of the population installing a given PTAC or PTHP unit which would experience life-cycle cost savings). In this analysis, the population is the number of PTAC and PTHP units in commercial building that utilize PTACs or PTHPs, including hotels and motels, assisted living and nursing homes, and small offices (mainly medical and dental).

Figure 8.4.2 presents the LCC results for the case of efficiency level 4 for the standard size PTAC with a cooling capacity of 9,000 Btu/h using R-410A refrigerant. Similar figures for other efficiency levels are found in appendix E for all equipment classes. In Figure 8.4.2, the 50-percent line shows the median change in LCC (a loss of $15.86 in this example). Half of the purchasers of this PTAC unit would lose more than $15.86 while half would lose less than $15.86. The "0" horizontal line is the minimum savings value, which in this example is a loss of $46.34 due to the increased efficiency at efficiency level 4 costing more than the baseline efficiency. The maximum LCC savings is $311.90, which is not displayed in Figure 8.4.2.

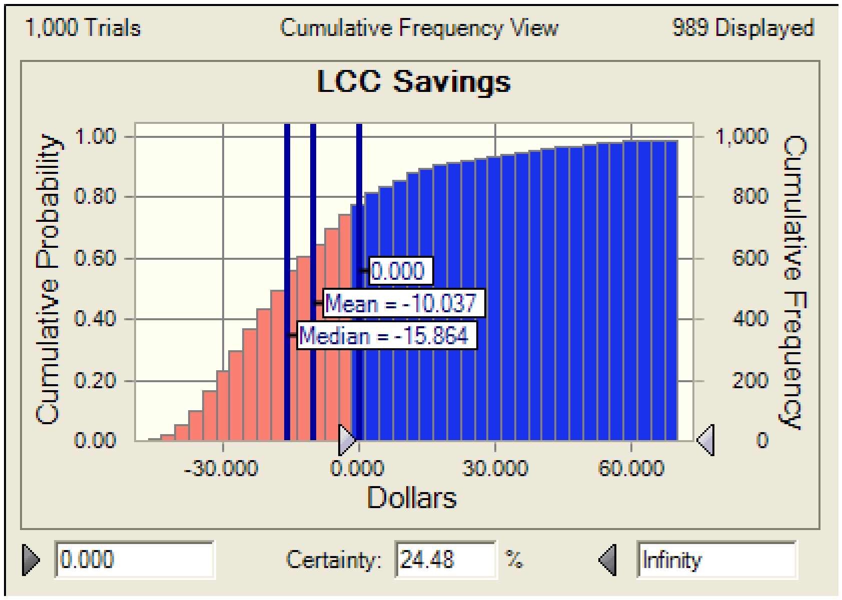

Figure 8.4.2 Cumulative Chart of LCC Savings for Standard Size PTAC, Cooling Capacity of 9,000 Btu/h, at Efficiency Level 4

Appendix E contains the cumulative charts for all the efficiency levels considered for all PTAC and PTHP equipment classes. These charts provide more complete information, but DOE provides a summary of the change in LCC for standard size PTAC 9000 R-410A from the baseline by percentile groupings (i.e., of the distribution of results) for each of the equipment classes in Table 8.4.1. Table 8.4.1 also shows the mean LCC savings and the percent of equipment with LCC savings from baseline for each efficiency level.

Table 8.4.1 Distribution of Life-Cycle Cost Savings from Baseline Level for PTAC 9000 by Efficiency Level

Efficiency	Decrease in LCC from Baseline Efficiency (Level 0) Shown by Percentiles of the Distribution of Results (2007$)*											Mean Savings	Percent of Units with LCC Savings
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%		
Level 1	-$14	-$10	-$8	-$7	-$5	-$3	-$2	$1	$3	$8	$111	-$1	33%
Level 2	-$24	-$17	-$15	-$12	-$10	-$7	-$4	$0	$5	$13	$182	-$3	31%
Level 3	-$35	-$25	-$22	-$18	-$15	-$11	-$7	-$2	$5	$15	$249	-$6	27%
Level 4	-$46	-$34	-$30	-$25	-$21	-$16	-$11	-$4	$4	$17	$312	-$10	25%

* Negative values refer to LCC increases compared to the baseline efficiency levels.

An example of standard size PTAC 9,000 Btu/h cooling capacity at efficiency level 4 can provide an interpretation of the data in Table 8.4.1. Level 4 efficiency in Table 8.4.1 shows that at the zero-percentile (second column), the LCC savings is -$46. This means that at the zero-percentile point, the LCC for a PTAC unit at efficiency level 4 is higher than for a PTAC unit at the baseline efficiency level, thus LCC savings are negative. This also means that the remainder of the market (the effectively 100 percent of the market above the zero-percentile point) are estimated to either have an LCC loss of less than -$46, or show a positive LCC savings. For 90 percent of the cases studied (all columns between the zero-percentile and the 90th percentile column), the change in LCC at efficiency level 4 is a LCC savings of $17 or less compared with the base case (i.e., a savings of $17 or less shown in the table). The largest positive LCC savings is $312 occurring for the 100th percentile of the distribution. The mean change in LCC is a loss of $10 compared with the baseline. The rightmost column shows that 25 percent of the customers show LCC savings compared with the baseline.

Table 8.4.2 provides the national average life-cycle cost savings calculated for each efficiency level when compared to the baseline (Level 0) for all equipment classes. Review of Table 8.4.2 shows that every efficiency level analyzed generated both positive and negative national average life cycle cost savings compared with the baseline.

Table 8.4.2 Average Life-Cycle Cost Savings from a Baseline Level by Efficiency Level and Equipment Class

Equipment Class	National Average LCC Savings (2007$)*			
	Level 1	Level 2	Level 3	Level 4
PTAC 9000	-$1	-$3	-$6	-$10
PTAC 12000	-$2	-$5	-$10	-$15
PTHP 9000	$11	$20	$28	$24
PTHP 12000	$13	$24	$20	$14
PTAC 11000	$26	$30	$31	NA
PTHP 11000	$62	$66	$80	NA
	Percent of Units with Positive LCC Savings from Baseline			
	Level 1	Level 2	Level 3	Level 4
PTAC 9000	33%	31%	27%	25%
PTAC 12000	31%	29%	25%	21%
PTHP 9000	71%	77%	79%	71%
PTHP 12000	71%	77%	67%	57%
PTAC 11000	79%	73%	67%	NA
PTHP 11000	97%	95%	93%	NA

* Negative values refer to LCC increases compared to the baseline efficiency levels. NA means that this efficiency level was not evaluated (PTAC 11000 and PTHP 11000 only were evaluated up to Level 3).

Appendix E contains similar tables for all the efficiency levels considered for all PTAC and PTHP equipment classes using R-410A refrigerants that correspond to the groups of figures contained in the same appendix.

8.4.2 Payback Period Results

This section presents PBP results for each efficiency level defined in section 8.3. The results presented here are based on annual operating costs calculated from state average commercial electricity prices. Section 8.2 describes the electricity price inputs as well as all other PBP inputs.

Similar to LCC, the PBP analysis provides an estimate of the simple payback period at different ranges of energy prices, sales taxes, and installation costs that prevail across the country for each efficiency level and each building (building) type. Figure 8.4.3 shows the effect on payback period as the level of efficiency changes from Level 0 (the baseline), for PTAC 9000 R-410A equipment class in large chain hotels at U.S. national average energy prices, sales taxes, and installation costs.

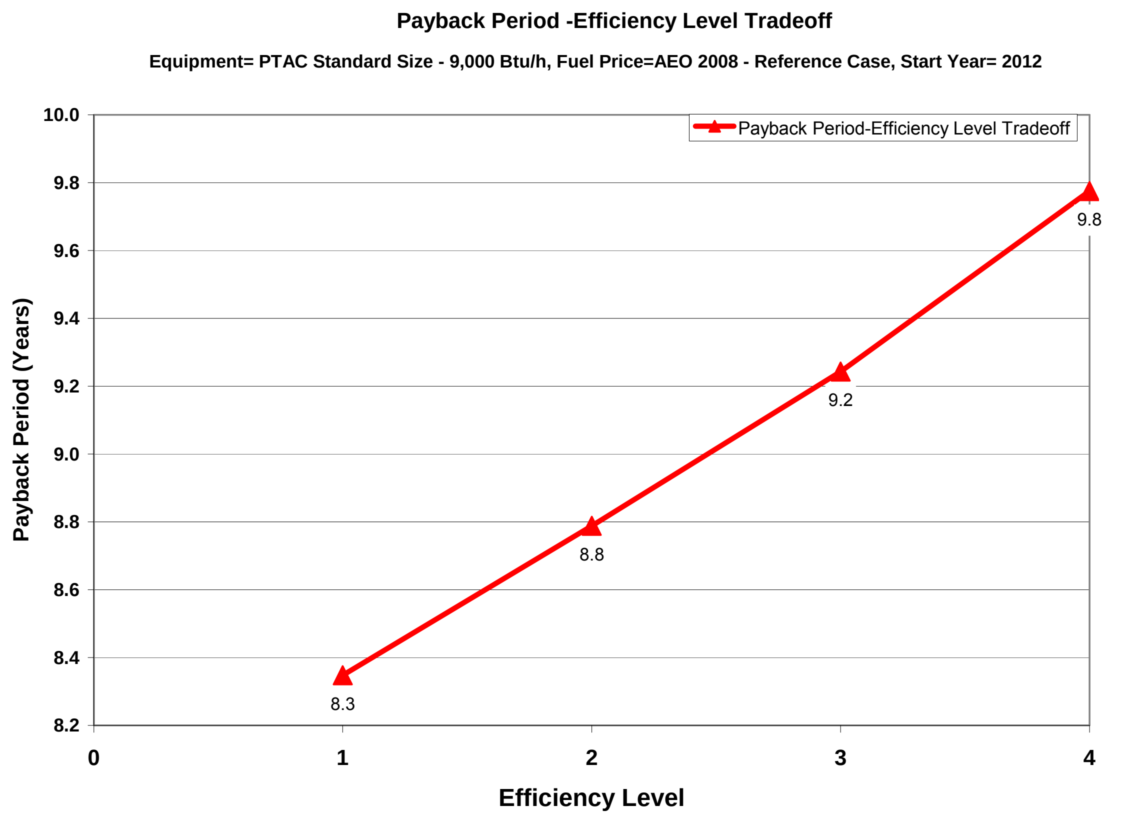

Figure 8.4.3 Effect of the Change in Efficiency Level on Payback Period for Standard Size PTAC 9000 in Large Chain Hotels at Average U.S. Conditions (Level 0 is the Baseline Level).

Similar to the LCC differences, DOE depicted PBP results as a distribution of values (Appendix E). Thus, it presents the results as a cumulative probability chart showing the distribution of PBPs with the corresponding cumulative probability of occurrence. Each chart provides the mean PBP. Figure 8.4.4 is an example of a cumulative probability chart showing the distribution of payback periods at efficiency level 4 for the standard size PTAC 9000 R-410A equipment class. Appendix E contains the frequency charts for all the efficiency levels considered for all PTACs and PTHPs equipment in this analysis. In Figure 8.4.4, the y-axis shows cumulative percent of all PTAC 9000 units (“Probability” at left y-axis). The x-axis is the PBP of a higher efficiency level (in this example, Level 4) relative to the baseline efficiency level (Level 0). In Figure 8.4.4, an efficiency level 4 provides standard size PTAC 9000 equipment with a median PBP of about 9.6 years, a mean payback period of 15.2 years, and a payback period range from about 1.3 years to over 100 years. (Note that these cannot be read with precision from the chart; rather, the analysis output data provides these values in a statistical summary.)

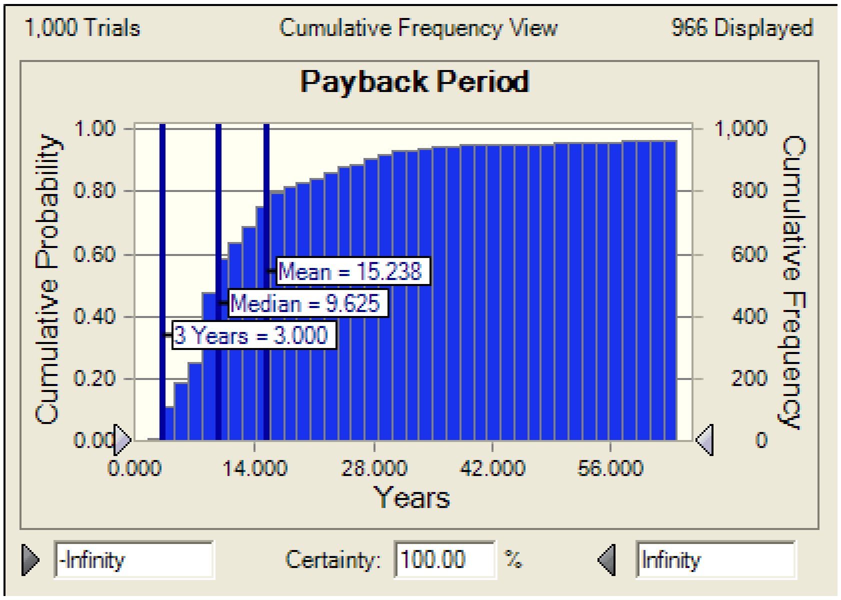

Figure 8.4.4 Cumulative Chart of Payback Period of PTAC 9000 at Efficiency Level 4

Table 8.4.3 summarizes the PBP results for the standard size PTAC 9000 R-410A equipment class. The results are summarized for PBP by percentile groupings (i.e., percentile of the distribution of results). The table also shows the mean PBP for each efficiency level.

Table 8.4.3 Summary of Payback Periods Results for Standard Size PTAC 9000 Equipment

Efficiency Level	Payback Period in Years Shown by Percentiles of the Distribution of Results											Mean
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	
Level 1	1.1	3.9	5.6	6.9	7.5	8.2	9.5	12.2	14.9	22.7	100.0	13.0
Level 2	1.2	4.1	5.9	7.2	7.8	8.6	10.1	12.9	15.5	24.5	100.0	13.7
Level 3	1.2	4.3	6.2	7.7	8.3	9.1	10.6	13.7	16.6	26.3	100.0	14.5
Level 4	1.3	4.5	6.5	8.1	8.7	9.6	11.2	14.5	17.6	28.2	100.0	15.2

Table 8.4.4 provides the national average payback calculated for each efficiency level when compared with the baseline efficiency level for each of six equipment classes analyzed. Table 8.4.4 also shows the percentage of units reporting payback periods of less than 3 years. The results of the analysis shown that payback period for purchases of higher efficiency levels (with respect to purchase of baseline units) was rarely less than 3 years for any of the efficiency levels considered for any equipment class. Table 8.4.4 shows that only non-standard size PTHPs contains certain efficiency levels (i.e., efficiency level 1, 2 and 3) that provides a payback of less than 3 years to at least 50 percent of units shipped.

Table 8.4.4 National Average Payback Periods by Efficiency Level and Equipment Class

Equipment Class	National Average Payback Period (Years)			
	Level 1	**Level 2**	**Level 3**	**Level 4**
PTAC 9000	13.0	13.7	14.5	15.2
PTAC 12000	13.1	14.0	14.9	15.9
PTHP 9000	5.1	4.5	4.4	5.1
PTHP 12000	5.1	4.6	5.5	6.4
PTAC 11000	4.4	5.1	5.9	NA
PTHP 11000	2.2	2.8	3.0	NA
	Percent of Units with Payback Period less than 3 Years			
	Level 1	**Level 2**	**Level 3**	**Level 4**
PTAC 9000	1%	1%	1%	1%
PTAC 12000	1%	1%	1%	1%
PTHP 9000	11%	19%	19%	9%
PTHP 12000	9%	17%	3%	1%
PTAC 11000	35%	21%	19%	NA
PTHP 11000	87%	67%	55%	NA

* NA means that this efficiency level was not evaluated (PTAC 11000 and PTHP 11000 only were evaluated up to Level 3).

8.5 LCC SENSITIVY STUDIES

Sensitivity analyses were conducted to evaluate how the LCC and PBP results change with changes in electricity price escalation rates. The results of these are discussed in section 8.5.1.

8.5.1 Sensitivity to Electricity Price Escalation Rate

Sensitivity to electricity price escalation rate was examined using the escalation rates provided in the *AEO 2008* high growth and low growth scenarios. Table 8.5.1 and Table 8.5.2 examine the national average LCC savings for the *AEO 2008* low growth scenario and *AEO 2008*high growth scenarios respectively. For the low growth scenario, while the average LCC savings is reduced for all efficiency levels above the baseline when compared with the reference case, there are no changes in the level showing the highest LCC savings when compared with the results using *AEO 2008* reference case (see Table 8.4.2). For the high growth scenario the average LCC savings is increased for all efficiency levels above the baseline when compared with the reference case.

Table 8.5.1 Average Life-Cycle Cost Savings from a Baseline Level by Efficiency Level and Equipment Class – EIA Low Growth Scenario

Equipment Class	National Average LCC Savings (2007$)*			
	Level 1	Level 2	Level 3	Level 4
PTAC 9000	-$2	-$5	-$8	-$12
PTAC 12000	-$3	-$7	-$12	-$18
PTHP 9000	$9	$17	$24	$20
PTHP 12000	$11	$20	$15	$9
PTAC 11000	$23	$26	$26	NA-
PTHP 11000	$57	$60	$72	NA
	Percent of Units with Positive LCC Savings from Baseline			
	Level 1	Level 2	Level 3	Level 4
PTAC 9000	29%	27%	23%	21%
PTAC 12000	27%	23%	21%	17%
PTHP 9000	67%	73%	75%	67%
PTHP 12000	67%	73%	61%	51%
PTAC 11000	77%	69%	63%	NA
PTHP 11000	97%	93%	93%	NA

* Negative values refer to LCC increases compared to the baseline efficiency levels. NA means that this efficiency level was not evaluated (PTAC 11000 and PTHP 11000 only were evaluated up to Level 3).

Table 8.5.2 Average Life-Cycle Cost Savings from a Baseline Level by Efficiency Level and Equipment Class – EIA High Growth Scenario

Equipment Class	National Average LCC Savings (2007$)*			
	Level 1	Level 2	Level 3	Level 4
PTAC 9000	-$1	-$2	-$5	-$8
PTAC 12000	-$1	-$4	-$8	-$13
PTHP 9000	$13	$23	$31	$28
PTHP 12000	$15	$27	$24	$18
PTAC 11000	$29	$34	$35	NA
PTHP 11000	$66	$71	$87	NA
	Percent of Units with Positive LCC Savings from Baseline			
	Level 1	Level 2	Level 3	Level 4
PTAC 9000	37%	33%	31%	27%
PTAC 12000	35%	31%	27%	23%
PTHP 9000	73%	81%	81%	75%
PTHP 12000	73%	79%	69%	59%
PTAC 11000	81%	75%	69%	NA
PTHP 11000	97%	95%	95%	NA

* Negative values refer to LCC increases compared to the baseline efficiency levels. NA means that this efficiency level was not evaluated (PTAC 11000 and PTHP 11000 only were evaluated up to Level 3).

Payback period is calculated based on first year energy savings and thus is insensitive to fuel escalation rate scenarios after the first year of operations. However, since the first year of operations is 2012, fuel price forecasts for 2012 do affect the payback forecast. As shown in Table 8.5.3 and Table 8.5.4, the payback periods are longer by approximately a year than in the reference case for the EIA Low Growth Forecast and shorter by approximately a year than in the reference case for the EIA High Growth Forecast, respectively.

Table 8.5.3 Average Payback Period by Efficiency Level and Equipment Class – EIA Low Growth Scenario

Equipment Class	National Average Payback Period (Years)			
	Level 1	Level 2	Level 3	Level 4
PTAC 9000	13.9	14.6	15.4	16.3
PTAC 12000	14.0	14.9	15.8	17.0
PTHP 9000	5.4	4.8	4.7	5.4
PTHP 12000	5.4	4.9	5.8	6.7
PTAC 11000	4.7	5.4	6.3	NA
PTHP 11000	2.3	2.9	3.1	NA
	Percent of Units with Payback Period less than 3 Years			
	Level 1	Level 2	Level 3	Level 4
PTAC 9000	1%	1%	1%	1%
PTAC 12000	1%	1%	1%	1%
PTHP 9000	5%	15%	15%	5%
PTHP 12000	5%	11%	1%	1%
PTAC 11000	27%	21%	17%	NA
PTHP 11000	85%	61%	47%	NA

Table 8.5.4 Average Payback Period by Efficiency Level and Equipment Class – EIA High Growth Scenario

Equipment Class	National Average Payback Period (Years)			
	Level 1	Level 2	Level 3	Level 4
PTAC 9000	12.1	12.9	13.6	14.3
PTAC 12000	12.2	13.2	14.0	15.0
PTHP 9000	4.8	4.3	4.2	4.8
PTHP 12000	4.8	4.4	5.2	6.0
PTAC 11000	4.2	4.8	5.6	NA
PTHP 11000	2.1	2.6	2.8	NA
	Percent of Units with Payback Period less than 3 Years			
	Level 1	Level 2	Level 3	Level 4
PTAC 9000	3%	1%	1%	1%
PTAC 12000	1%	1%	1%	1%
PTHP 9000	17%	25%	25%	13%
PTHP 12000	17%	23%	7%	1%
PTAC 11000	43%	25%	19%	NA
PTHP 11000	91%	73%	65%	NA

8.6 DETAILED RESULTS

DOE presents more detailed results and supporting data for the LCC analysis in appendix E.

REFERENCES

[1] Damodaran Online. Leonard N. Stern School of Business, New York University: http://www.stern.nyu.edu/~adamodar/New_Home_Page/data.html. January, 2008.

[2] Energy Information Administration. 2008b. Form EIA-826 Database Monthly Electric Utility Sales and Revenue Data ("EIA-826 Sales and Revenue Spreadsheets"). http://www.eia.doe.gov/cneaf/electricity/page/eia826.html. Accessed May 8, 2008..

[3] EIA (Energy Information Administration). 2003. 2003 Commercial Building Energy Consumption Survey (CBECS), Public Use Data, Micro-data files on EIA website: http://www.eia.doe.gov/emeu/cbecs/cbecs2003/public_use_2003/cbecs_pudata2003.html (Accessed October 11, 2006).

[4] EIA (Energy Information Administration). 2008a. *Annual Energy Outlook 2008.* EIA, Washington, D.C., DOE/EIA-0554 (2008).

[5].American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). 1999. *ASHRAE/IES Standard 90.1-1999, "Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings*." Atlanta, Georgia.

[6] R.S. Means Company, Inc. 2008. RS Means CostWorks 2008. http://www.meanscostworks.com. Accessed March 30, 2007.

[7] Carrier Corporation (Carrier). 2007. Lodging AC Warranty. http://www.lodgingac.carrier.com/details/1,,CLI1_DIV19_ETI1052,00.html?SMSESSION=NO

[8] Harris, Robert S., "Applying the Capital Asset Pricing Model". UVA-F-1456 Available at SSRN: http://ssrn.com/abstract=909893

[9] Executive Office of the President. 2008. *2008 Economic Report of the President*, *Washington, D.C.*